Advanced Deep Space System Development Program
Future Delivery Element

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Advanced Deep Space System Development *Future Delivery* Summary

- Responsible for all ADSSD deliveries after the first
- The Second Delivery:
  - Delivery date is proposed to be 9/03
  - Will have ~$100M
  - Includes complete flight/ground system
    - engineering subsystems and instruments and S/W tested to TRL 6 on the ground
  - Mission Architecture is open i.e. could include other than a “spacecraft” e.g. aerobots, penetrators, rovers, others
  - Primary Constraints on the Design of the Second Delivery Include:

    1) Taking advantage of First Delivey/being integrated with the First Delivery

    2) Needs of the future outer planet missions

    3) Including a strong “technology push”
       - Second Generation Microspacecraft Concept
- Will collaborate with NASA Centers, Industry, University and OGA “partners” and “observers”
- Primary task in FY-98 is to create a small number [2-4] of feasible design points for the Second Delivery that are consistent with the 3 Primary Design Constraints

ADSSD Future Delivery Technical System Architecture Issues

1) fault tolerant or highly reliable?
2) centralized or distributed computing?
3) on board data processing; what, when and where?
4) deterministic or non deterministic state control of the FSW?
5) survey science [sense all parameters @ a pt in space] or focused science missions?
6) multi-functional systems or modular functions in separate boxes?
7) multi mission s/c or specialized s/c?
8) hot, cold or room temp s/c?
9) S/W technology, what, why, how
10) solar and/or nuclear power sources; what, when and where
11) Solar Sail and/or SEP and/or chemical propulsion, what, when and where
12) large aperture-gossamer spacecraft; what, when, where
13) integrating science instruments into the engineering technology

Starting Point for X2000 Second Delivery Design

Second Generation Microspacecraft Concept for Outer Planet Flyby Mission

First Planned Change is from RF telecom to a Multi-Functional Telescope serving Science and Optical Telecom

SCIENCE FOCUS: IMAGING AND IMAGING SPECTROSCOPY

POWER: 0.1-15 W LAUNCH SIZE: 46 CM DIA. X 30 CM LAUNCH MASS:

REQUIRED UPLINK: NONE

CORE BUILDING BLOCK CAPABILITIES

High-Capability Microcomputer

High-Density Mass Memory

Autonomous Control

High-Efficiency Data Compress

Integrated Optical Sensing

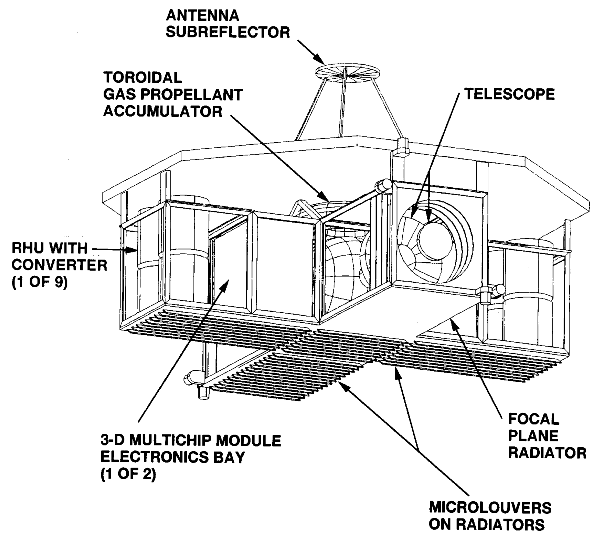
Efficient Power Management

High-Efficiency Power Convers

Compact Power Switching

Low-Power Ka-Band Excit. / Mo

High-Efficiency Ka-Band Amp.



OTHER KEY CAPABILITIES

Very-Small, Low-Power IRUs

High-Energy-Density Batteries

High-Heat-Conductivity Materi

Variable Emissivity Microradi

Low-Mass Insulation

Low-Power Microvalves

Low-Mass Pressure Transducers

Low-Mass Propellant Tanks

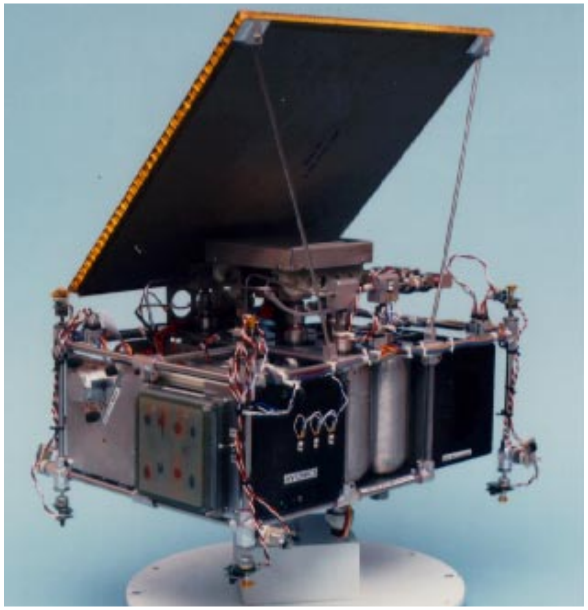
Low-Mass Structure

SPECIAL, MISSION SPECIFIC CAPABILITIES

RHU-Based, Thermoelectric Power Source Precision Clock & Timer

Low-Mass MGA Supplemental On-Board Data Analysis Optional Microinstru

MICROSPACECRAFT TECHNOLOGY DEVELOPMENT DELIVERY #2, 9/96



OBJECTIVE:

Develop/integrate technology leading towards the Second Generation Microspacecraft

SYSTEM ARCHITECTURE:

Second Generation Microspacecraft for near Earth object flyby.

IMPLEMENTATION:

Designed/built in 5 months for primarily with commercially available parts. Designed to have most of the functionality of the Second Generation Microspacecraft. The required performance will be implemented with technology development in subsequent demonstrations. This hardware was not designed for flight. This spacecraft is one of the smallest 3 axis controlled spacecraft in the world.

DESIGN FEATURES:

Size: 25x35x40 cm

Power: ~10w GaAs solar array, 1.2 Ahr [20 whr] Lithium Ion rechargeable batteries

Mass: 8.9 kg

Propulsion: Nitrogen cold gas for control, MEMS valves; delta V functionality not included

Control: 3 axis solid state rate sensors

Communications: wireless LAN

Data Processing: 486 33Mhz based with 20 Mbyte of Flash RAM

Structure: Propellant tubing [stainless steel] used as prime structure

Instrument: APS visual demo

DESIGN "FIRSTS" for this delivery:

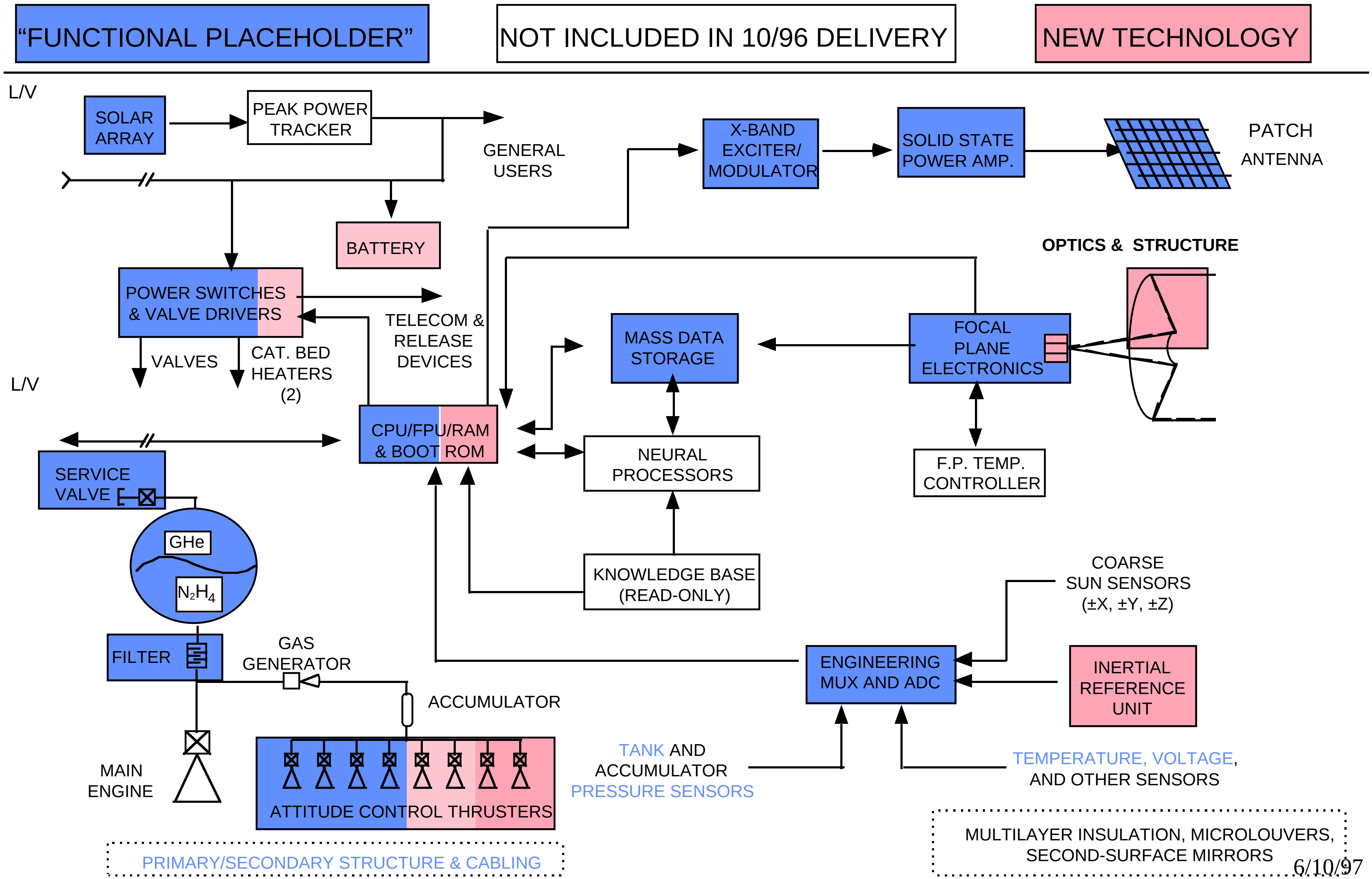
MEMs micro-gyro from JPL MDL/CMST

Composite Silicon Carbide structure

Elastomeric Connector used for avionics packaging [now to be used on NMP DS#1]

10/96 MTD Hardware Compared to Functional Requirements of SGM

Near Earth Object Flyby Mission/System

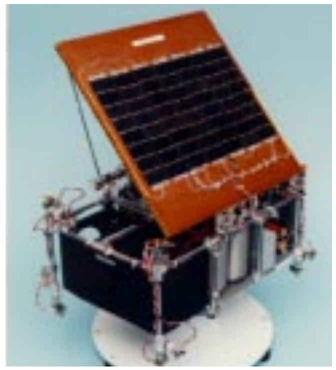


Enable Future Microspacecraft Through Agressive Technology Development

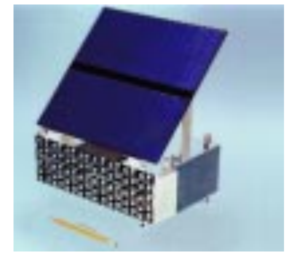
Deliver System Demonstrations Every 6 Months

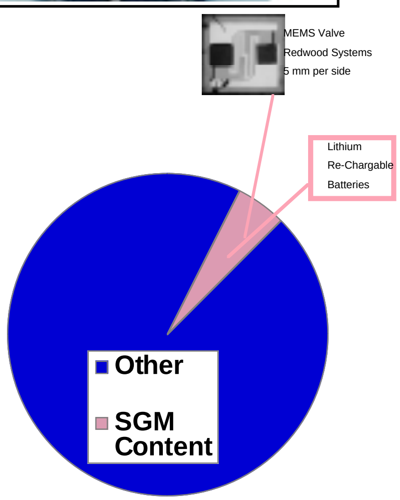
MSC I: 4/96
System Demonstration
10kg, no instruments, no autonomy, MEMS valves, 1st step toward Second Generation Microspacecraft

MSC II: 10/96
System Demonstration
MSC I + MEMS gyro, SiC Structure, APS Camera

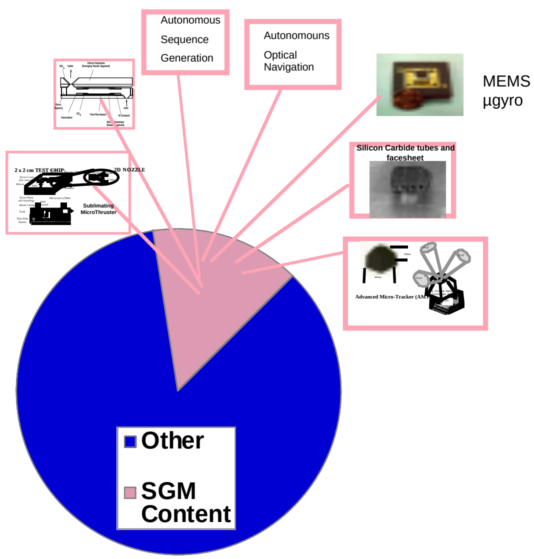


Second Generation Microspacecraft
5 kg, visual & spectral imaging; highly autonomous



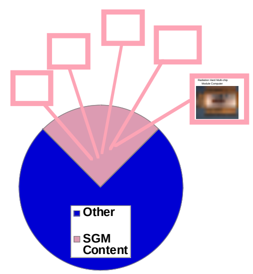


SGM Technology Content in 4/96 Demo



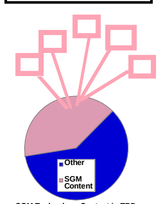
SGM Technology Content in 10/96 Demo

10/97
System Demonstration
3rd step toward Second Generation Microspacecraft

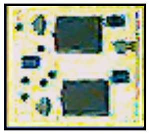


SGM Technology Content in 10/97 Demo

Future System Demonstration steps toward Second Generation Microspacecraft

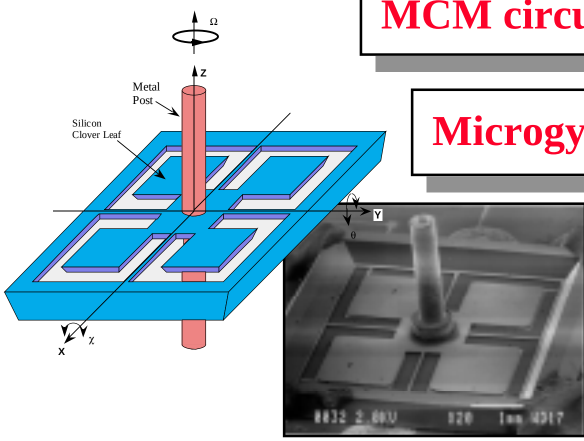


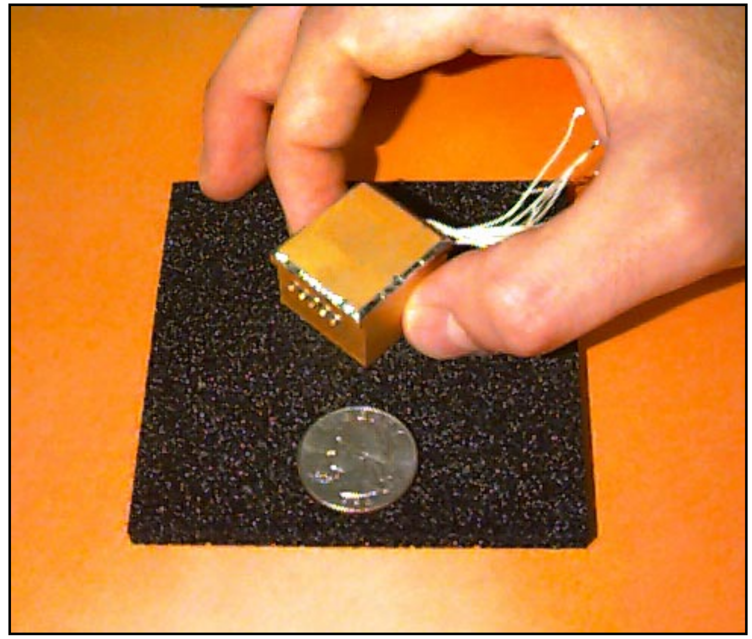
SILICON MICROMACHINED MICROGYROSCOPE



MCM circuit

Microgyro





Resonant Frequency	Drive:452 Hz, Sense: 447 Hz
Driving Voltage	4 V (p-p)
Q-factor	~500
Scale Factor	10.4 mV/deg/sec ; BW=1 Hz
Scale Factor Nonlinearity	< 1 %
Bias Instability (1 s)	< 29 deg/hr
Angle Random Walk	1.5 deg/ rt-hr
Mininum Noise Equivalent Rate	90 deg/hr; BW =1 Hz

Future Plan

1) Achieve 1 - 10 deg/hr bias stability.
2) Develop a three-axes Micro-Inertial Measurement Unit.
3) Space validation of the microgyroscope.

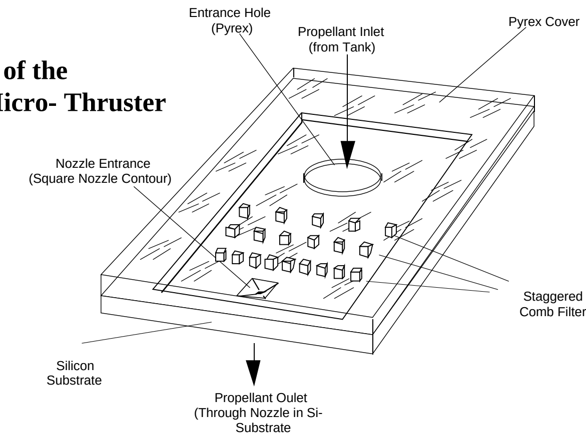
JPL

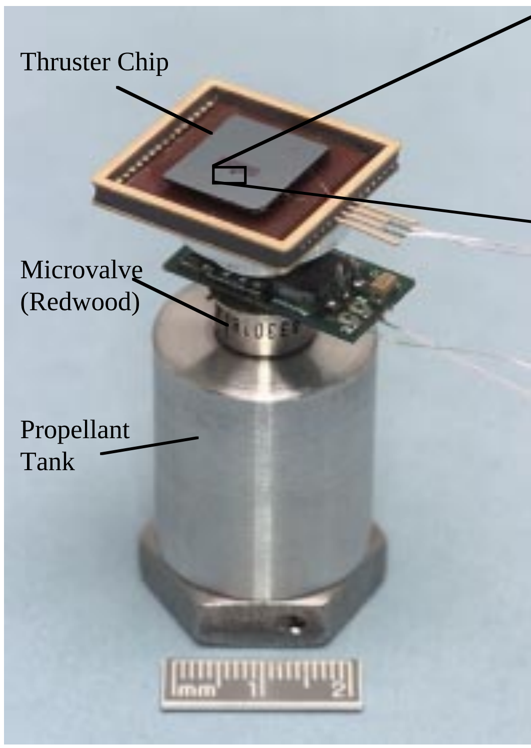
Subliming Solid Micro-Thruster

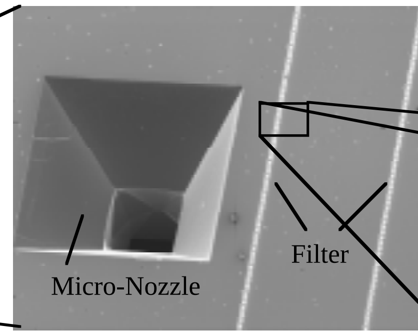
Principle of Operation:

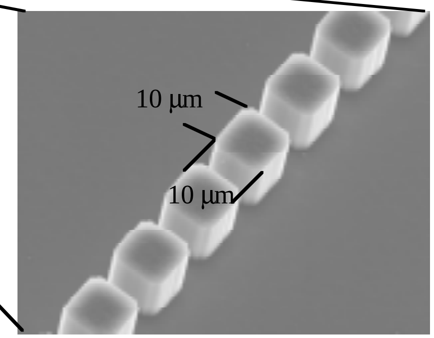
- **Store propellant (ammonium salt) in solid form.**
- **Propellant sublimes when heated, building up pressure in tank (~10-15 psia)**
- **Vent gaseous propellant through micro-valve, micro-filter and micro-nozzle assembly to produce thrust.**

Concept of the Subliming Solid Micro- Thruster









Benefits:

- **Phase-change thruster concept, reduces leakage problem.**
- **Very small thrust and I-bit capability for microspacecraft attitude control through the use of MEMS technologies.**
- **Benign temperature and pressure conditions compatible with MEMS materials.**

Performance Goals:

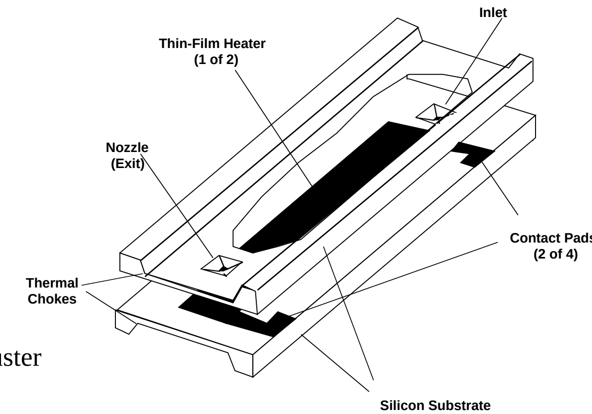
- **Isp : 50-75 sec**
- **Thrust: 0.5 mN**
- **Power: < 2 W/mN**
- **Mass: few grams**
- **Size: 1 cm²**

JPL

Vaporizing Liquid Micro-Thruster

Principle of Operation:

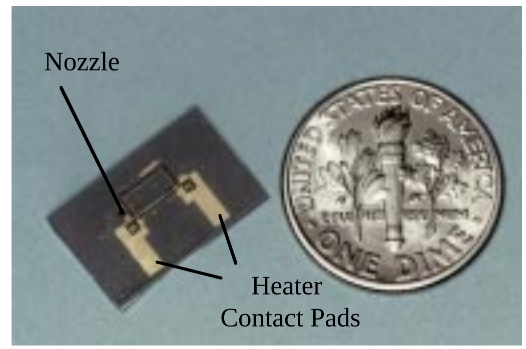
- Liquid propellant (water, NH_3 , N_2H_4) is pressure-fed into thruster (low complexity).
- Liquid propellant is vaporized in micro-fabricated thin-film heat exchanger.
- Gaseous propellant exits nozzle to produce thrust(micro-resistojet concept).



Concept of the Vaporizing Liquid Micro-Thruster

Benefits:

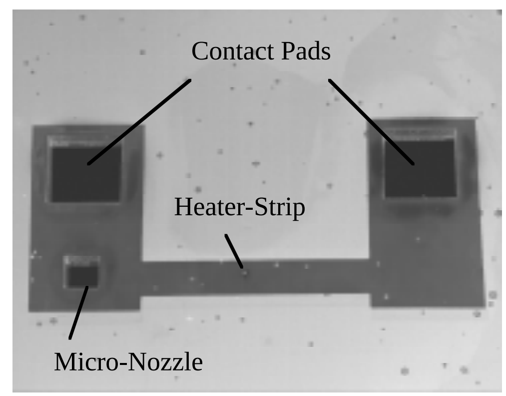
- Phase-change thruster concept, reduces leakage problem.
- Very small thrust and I-bit capability for microspacecraft attitude control through use of MEMS technologies.
- Benign temperature and pressure (<50 psia) conditions compatible with MEMS materials.



Vaporizing Liquid Micro-Thruster Chip

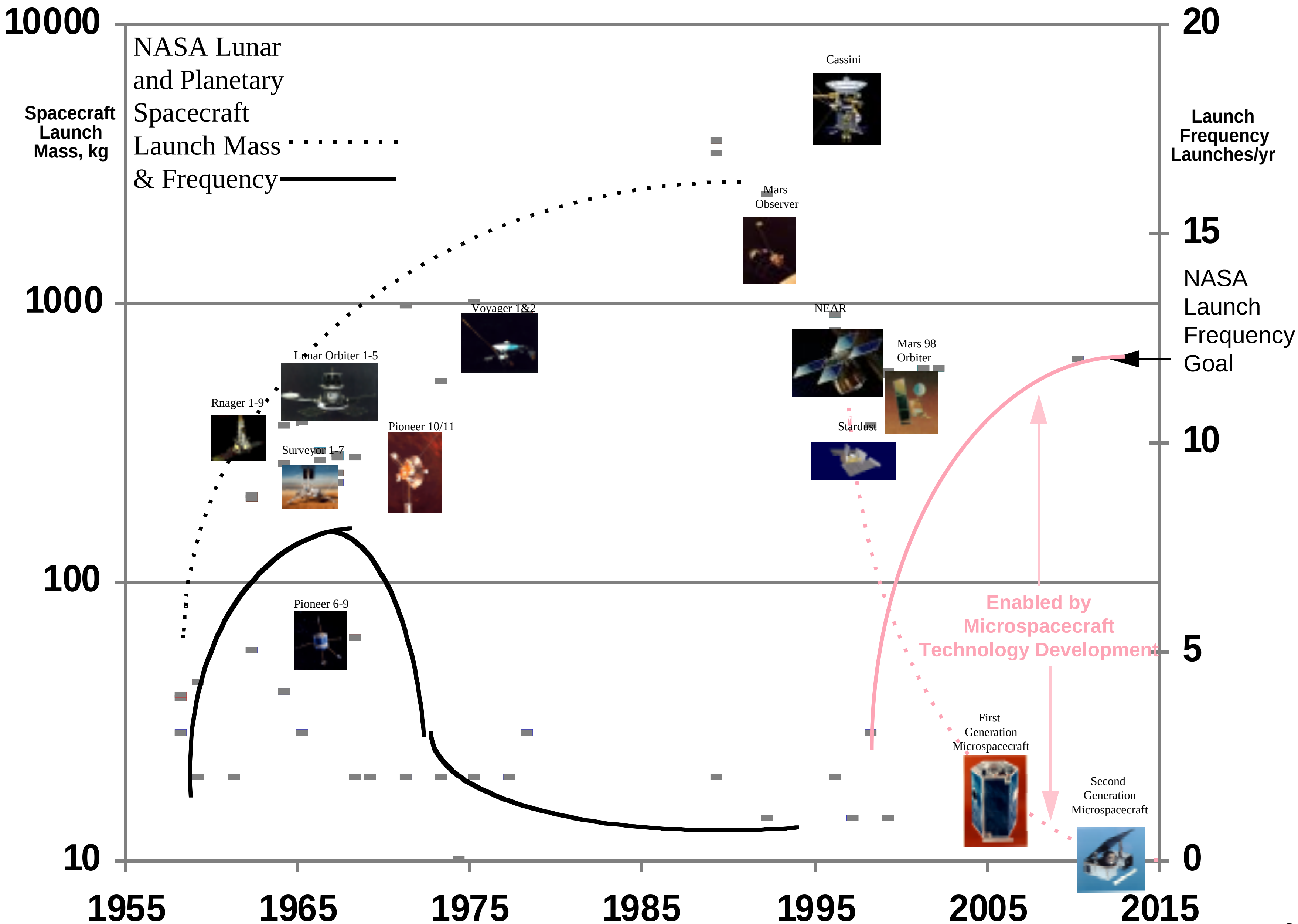
Performance Goals:

- Isp: 75-125 sec
- Thrust: 0.5 mN
- Power Consumption: < 5 W
- Efficiency $\geq$ 50 %
- Mass: few grams
- Size: 1 cm^2



Micro-Heater Detail

Microspacecraft Technology Development Enables NASA's Science Mission Launch Frequency Goals



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